Disentangling the effect of students' maturity on academic achievement

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There exists an increasing number of contributions focused on the influence of the attendance to early childhood and/or preprimary education on the future academic path of the students, which employ in a complementary way the quarter of birth of the student as a proxy for the maturity of the children. The present work goes a step further by making a distinction between three different dimensions of maturity: students' mental age, proxied by the time when children began to exhibit the basic competences (reading and writing); chronological age, represented by the bimester of birth; and grade repetition, which represents a maturity related to academic knowledge.
The suitability of the quarter of birth and the ages of beginning to read and write as an instrument of repetition has been checked, finding that they are not adequate for this purpose This finding might be reinforcing the argument that the ages of beginning to read and write, the quarter of birth and grade repetition might be measuring different dimensions of students' maturity.
Keywords: Maturity; writing; reading; grade repetition.
Acknowledgements: This work has been partly supported by the Andalusian Regional Ministry of Innovation, Science and Enterprise (PAI group SEJ-532 and Excellence research group SEJ-2727); the Ministry of Economy and Competitiveness of Spain (Research Project ECO2014-56397-P) and the scholarship FPU2014 04518 of the Spanish Ministry of Education. Luis Alejandro Lopez-Agudo also acknowledges the training provided by the *Programa de Doctorado en Economía y Empresa de la Universidad de Malaga*.

1. INTRODUCTION

Students' maturity has been highlighted as a relevant element conditioning students' future achievement (e.g., Bedard and Dhuey, 2006) In fact, the relevance of maturity extends further from primary and secondary education to students' academic and career pathways, receiving –in this case– the denomination of "career maturity" (Creed & Patton, 2003).

The achievement of students' career maturity supposes an essential objective, however is not so easy to delimit and measure, thus it has been frequently proxied by students' quarter of birth (Alet, 2010), which is said to increase students' achievement when the student has been born early in the year, while a late birth has a –comparatively– detrimental effect. Pedraja-Chaparro, Santín, and Simancas (2015) also highlighted the higher likelihood of repeating a course of students who were born in the last months in Spain and France –using data from PISA 2009-. This proxy has also been employed by some researchers to analyze how the attendance to previous courses of compulsory education (as early childhood education –before age 3– or preprimary education –age 3 to 5–) might help to reduce the potential disadvantage that students who were born in the fourth quarter of the year could present. In this regard, authors as Hidalgo-Hidalgo and García-Pérez (2012) analyzed the effect of the attendance to preprimary education on the negative impact that supposes being born in the fourth quarter of the year. They found that students who were born by that term and took these courses got better results, due to their help in overcoming –to some extent– the difficulties that they could be facing as a consequence of their maturity differences with older students in the classroom. Alternatively, González-Betancor and López-Puig (2015) studied the effect of early childhood education –before age 3– and the quarter of birth –as a proxy of students' maturity– in the education achievement of students in the fourth course of primary education. They found that the achievement of these students was higher when they had attended to kindergartens, what also helped students who had been born in the fourth quarter of the year to obtain better academic achievement.

Focusing on the effect of maturity along students' academic progression, Bedard and Dhuey (2006) remarked that, in spite of the expected disappearance in successive courses of the influence on students' achievement of the relative differences in the age of students, those who began with a higher age were more likely to attend to pre-university academic programs. Ponzo and Scoppa (2014) analyzed students of fourth, eight and tenth grade and emphasized that the lower scores of students born in the third and fourth quarter of the year –compared to older students– is kept during all the academic track of the student. A similar effect was found by Gutiérrez-Domènech and Adserà (2012), for Catalan students in second, fourth and sixth grade. Likewise, Cunha, Heckman, Lochner, and Masterov (2006) established that differences in starting ages could perpetuate along the years, as older students are able to retain more skills than younger ones due to their maturity. However, Robertson (2011) claimed that younger students increase their achievement until reaching that of the older ones in successive courses.

An important issue is that of the potential endogeneity problems caused by the inclusion of repeater and non-repeater students in the same specification –due to the propensity of school failure and academic achievement to be simultaneously determined–. García-Pérez, Hidalgo-Hidalgo, and Robles-Zurita (2014) showed that students who repeat a course present the worst learning characteristics so that, as these characteristics are unobservable, the obtained differences between repeaters and non-repeaters in academic achievement would be biased. Hence, they suggest using the quarter of birth –representing students' maturity– as instrumental variable of grade repetition. However, this has been highlighted by many international researches to be an imprecise methodology and a source of inconsistent estimates, because it does not satisfy the monotonicity property (Barua & Lang, 2011). This is due to differences in school entry ages: as the legal entrance to the course is in September, children born in the first and second quarters of the year may be entering to the course with a higher age than those born in the last quarter and, then, with some "advantage". In addition, some parents may delay the entrance of the latter group of children for the next year in order to avoid this disadvantage. Thus, the quarter of birth may not be affecting in the same direction all individuals. In the same vein, Buckles and Hungerman (2010) also remarked that the quarter of birth is not a proper instrument, to the extent that it is not randomly distributed, because it is conditioned by the fertility patterns that different family socio-economic backgrounds present.

Building on the revision of the previous literature, this research first contribution consists of disentangling the potential effect on student's achievement of three different proxies for students' maturity, i.e., the bimester of birth[145] –bi-monthly aggregation of months–, the ages at which the student learnt to read and write[146] and students' grade repetition. As it has been highlighted, the use of students' date of birth has been severely criticized, so we propose to use it as a regressor together with the ages at which students began to read and write to check the robustness of our results. This will let us to control whether the effect of the ages of beginning to read and write would be due to it properly proxying students' maturity or a consequence of the omission of the bimester of birth[147]. The third dimension of maturity under scrutiny is that related to academic content knowledge, which would be proxied by grade repetition.

This approach lets to determine the influence of these proxies of maturity on students' achievement, what could be translated into policy interventions aimed at, e.g., helping those students who have difficulties in the learning of reading and writing skills in early stages of

[145] In this research the bimester of birth has been employed instead of the quarter of birth as it provides richer information while not compromising the degrees of freedom. However, every analysis in this research has also been performed with the quarter of birth and the results do not vary –these results will be provided upon request to the authors–.

[146] We also have information on the age at which the student learnt to speak, but this skill is more related to psychomotor ones than competences, so we are not studying it in this research.

[147] Stern (1912) proposed the IQ concept as the quotient between "mental age" and "chronological age" (multiplied by 100). The concept of "chronological age" of a student corresponds to his/her actual age, while a subject's "mental age" (concept coined by Binet and Simon in 1908) is "(…) based on his or her performance compared with the average performance of individuals in a specific chronological age group. In simple terms, if a 6-year-old can perform the tasks that can be done by two-thirds to three-fourths of the representative group of 8-year-old children, then this child has a mental age of 8." (Kaplan & Saccuzzo, 2013, p. 241).

their lives. Concretely, these policy interventions could be reflected in the increase of public funding on preprimary education and enrollment.

In addition, the use of the ages of beginning to read and write as a proxy for maturity is a valuable contribution of this research in the context of the Spanish educational system. The link between maturity and learning to read and write has been highlighted, e.g., by Neuman, Copple, and Bredekamp (2000) or Cohen and Cowen (2008). They claimed that childhood experiences, which can enhance maturity, may be affecting the development of children literacy skills –reading and writing– since the very moment of their birth. This could be due to children learning literacy skills from different sources of their environment as television, advertisement boards, technological media, etc., what increases the relevance of following children's maturity development from an early stage of their lives.

The second contribution of this research intends to deal with the endogeneity problems that controlling by repeaters may cause in estimations. As the effect of a late birth in the year may be one of the main causes of repetition –due to students who are delayed in the acquisition of knowledge being expected to systematically get lower scores and enter in a "spiral of repetition"– we propose the use the bimester of birth as instrument of the repetition condition. However, it turned out to be a bad instrument[148] –like some international studies highlighted–, as it is correlated to the error term and, when used to instrument repeaters in 2SLS estimations, it did not correct endogeneity. This has discouraged its use for the purpose of analyzing students' maturity and has motivated the use of the ages of beginning to read and write as alternative instruments for repeaters, but they have presented the same problems as the bimester of birth. These results in instrumentalization of repeaters support the argument of our first contribution, which states that the ages of beginning to read and write, the bimester of birth and grade repetition may be measuring different dimensions of students' maturity. Nevertheless, due to the impossibility of solving endogeneity problems with the available data, repeaters are not studied together in the same specification with non-repeaters when explaining academic achievement and we will be focusing in the other two proxies of maturity: the bimester of birth and the ages of beginning to read and write.

2. METHODOLOGY

2.1. Data

The dataset employed in this research is that of the recent survey ESOC10 (Social Survey 2010: Education and Housing) conducted by the *Instituto de Estadística de Andalucía* (IECA). This survey comprises information on a wide set of personal, family and school environment characteristics for Andalusia. It was conducted in 2009/2010 among 2,448 students born in 1998 and 2,584 born in 1994, and their families. In addition, this survey was linked to the results from the administrative records (SENECA) of teacher-based scores –provided by the *Consejería de Educación de la Junta de Andalucía*– and to the Andalusian diagnostic assessment tests. The sampling procedure employed was a stratified multistage sampling.

[148] The quarter of birth provided similar results to the bimester of birth.

Firstly, households were stratified in two subsamples, according to whether their children were born in 1994 or 1998. In each subsample a three-stage conglomerate sampling with stratification in the first stage was employed. The units of the first stage were composed by census sections, those of the second stage were households and, in the third, the child of the corresponding age group was selected. This combined database (renamed as ESOC10-SEN) was further reduced by removing those students who presented some kind of disability, attended to a private school or about whom the database does not have information on these aspects. These filters left us with a subsample of 2,263 observations for students born in 1994 and 2,205 for those born in 1998. Furthermore, we made use of a missing flag procedure in order to control for those individuals who did not provide information about their household income level, ages when their child began to read or write or the child's bimester of birth.

2.2. Variables

A set of variables which has been shown in the Economics of Education literature as good predictors of students' achievement has been chosen for this research. Concretely, these variables are: students' sex, immigrant status[149], school funding –semi-private or public–, education level of the father and the mother, the household level of income, the ages at which the student began to read and write[150] and the bimester of birth, all of them from ESOC10. The information about grade repetition was obtained from administrative records (SENECA). Although the variables on the ages when the student began to read and write originally presented a continuous structure, they have been split in many categories according to their distribution, in order to pick up their potential non-linearities. The results related to them should be taken with caution, as parents may not remember accurately the ages when their children began to read or write. However, in spite of this, the lack of empirical applications –to the best of our knowledge– which make use of these variables to analyze maturity –due to the difficulty to find a database which contains information about them– highlights the relevance and novelty of the current research. As dependent variable, students' scores in diagnostic assessment tests[151] were chosen, as they measure students' competences, which are more related to maturity than the knowledge in a certain subject –administrative records of teacher-based scores or "real scores"–. These scores in diagnostic assessment tests will be those referred to the linguistic communication and mathematical competences, which are measured in a scale with an average of 500 points and standard deviation of 100.

[149] First and second generation immigrant students can not be differenced. Nevertheless they suppose a low percentage of students in Andalusia (0.35%, as reported by PISA 2012).

[150] Specifically, it was asked in the parental questionnaire: "In which age does the child began to: 1) read 2) write. Parents could answer the number of years, the number of months, "He/she has not begun yet", "Do not know", "No answer" and "Not applicable".

[151] The selection of this dependent variable reduces the sample of 1994 to 1,597 observations –1218 non-repeaters and 379 repeaters– and that of 1998 to 1,868, all of them non-repeaters. Although there are repeater students born in 1998 in the database, unfortunately the structure of the survey supposed that information on their diagnostic assessment test scores was not provided.

2.3. Procedure

The estimation procedure used in this research has been ordinary least squares (for Tables 1, 2, 3, 4 and 7). Although a multilevel analysis could seem as a more suitable approach than ordinary least squares, the ESOC10-SEN dataset does not have representative information by schools –the average of students per school is 3–, what hinders the use of this estimation procedure. The variables which represent the ages at which students learnt to read and write were included in alternative specifications in order to avoid the potential bias of the estimates when including them simultaneously. Additionally, as a robustness check for different dimensions of maturity, we plug in both alternative specifications the bimester of birth –in Table 4 for non-repeater students born in 1994–,to determine whether its effect would be taking part of that from the ages when the student began to read and write or not. We will focus on students born in 1994, as information about both non-repeaters and repeaters is only available for diagnostic assessment test scores in this cohort and grade retention is one of the main maturity proxies of this research. The data for the cohort of students born in 1998 will be employed as robustness check, as it will be explained in the Results' section.

3. RESULTS

In what follows the main results of this research are presented. The results of the bivariate analysis show that, for 14-15 years old non-repeater students, scores in the linguistic communication and mathematical competences present a decreasing trend with the ages of beginning to read and write, so a late start in these practices supposes lower scores in those competences; same applies to those born in the last bimesters of the year. In the case of repeaters this trend is not so obvious, although a late start in reading and writing has a similar effect.

In order to evaluate whether the results from the bivariate analysis are hold when conditioned on other variables, Table 1 presents the results for the main specification in the case of non-repeater and repeater students aged 14-15. These results show that female students obtain higher results than males in linguistic communication competence (as indicated by OCDE, 2010; OECD, 2014). Furthermore, immigrant students present lower results in linguistic communication and mathematical competences (Ammermüller, 2007; Calero, Choi, & Waisgrais, 2010) and students who attend to semi-private schools have higher results in both competences. A high level of fathers' education increases the academic achievement in the linguistic communication competence, while a high income level of the household increases it in the mathematics competence. Mothers' high level of studies increases the academic achievement in both competences, as highlighted by authors as González and De la Rica (2012). In fact, PISA reports have highlighted this same result, claiming that in Spain those children whose parents have obtained only an elementary education level perform –in standardized tests– about one standard deviation below children from families with higher education studies (OECD, 2010). Plug and Oosterbeek (1999) also support this argument; they estimate that an increase of around 5 years in the parents' studies results in an additional year of study of the child.

Table 1. Estimation of the conditional effect on academic achievement of socio-economic variables (non-repeaters and repeaters, 1994 cohort)

Variables	Linguistic Communication Competence	Mathematical Competence
Female (*Reference group: Male*)	42.971***	-7.003
	(5.681)	(5.942)
Immigrant (*Reference group: Native*)	-33.556**	-59.211***
	(16.913)	(17.691)
Semi-private school (*Reference group: Public school*)	48.907***	20.824***
	(7.187)	(7.518)
Father's education level (*Reference group: Lower than primary*)		
Primary	-0.476	-5.151
	(12.337)	(12.905)
Secondary	13.928	0.213
	(10.308)	(10.783)
High school	35.211***	17.296
	(11.888)	(12.436)
University	39.616***	12.854
	(12.598)	(13.178)
Mother's education level (*Reference group: Lower than primary*)		
Primary	-13.628	-12.345
	(13.740)	(14.373)
Secondary	4.838	-2.114
	(12.292)	(12.858)
High school	28.484**	30.290**
	(13.218)	(13.827)
University	35.215**	30.383**
	(13.854)	(14.492)
Monthly income level of the household (*Reference group: 1100 Euros or less*)		
From 1101 to 1800 Euros	10.818	9.293
	(7.774)	(8.131)
From 1801 to 2700 Euros	17.150*	25.264**
	(9.482)	(9.919)
More than 2700 Euros	14.667	25.249**
	(12.208)	(12.770)
Missing flag	13.443	35.720***
	(11.442)	(11.969)
Constant	444.542***	489.947***
	(13.597)	(14.223)
Observations	1,030	1,030
R-squared	0.198	0.102

Source: Authors' own calculations from ESOC10-SEN.
Estimation method: OLS.
Standard errors in parentheses.
*** denotes variable significant to level 1%; ** to 5%; * to 10%.

Table 2 presents the same specification as Table 1 but when the repeater condition –the dimension of maturity related to academic knowledge– is controlled. These repeater students present a different education production function compared to non-repeaters, as repeater students have different characteristics that influence their own education attainment and, to the extent that these characteristics are unobservable, estimated differences in educational outcome between repeaters and non-repeaters may be biased under OLS, so the repeater condition variable would be a stochastic regressor. This problem is easily visible when taking into account that the inclusion of the repetition control variable increases the R-squared of the estimations in more than 10%, together with the high and significant impact of the coefficient of this variable and the loss of significance in the rest of conditional variables. As students could repeat one or more courses due to a delay in the acquisition of the necessary knowledge –because of their late birth– or due to their low mental maturity –proxied by the ages of beginning to read and write– it was checked whether or not these variables would be proper instruments for the repeater condition of students born in 1994. It was found that the bimester of birth satisfies the relevance requirement (to account for a significant variation in the endogenous variable–) but not the validity requirement (not being correlated to the error term). Hence, when used as an instrument of grade repetition in 2SLS estimations it does not work[152] for the sample under analysis –also postestimation tests support this conclusion[153]–, as highlighted in some international studies. This has motivated the use of the ages of beginning to read and write as alternative instruments for grade repetition. However, both variables presented the same problems as the bimester of birth when used as instruments[154]. Furthermore, there is not a proper instrument in this database for grade repetition. These results reinforce the argument which states that the ages of beginning to read and write, the bimester of birth and grade repetition may be measuring different dimensions of students' maturity.

As controlling by repeaters causes endogeneity problems in the results of the estimations, in the following the analysis will be focused on non-repeater students born in 1994. To perform this analysis, maturity will be proxied by the ages of beginning to read and write and the bimester of birth, which will be included in the estimations sequentially. Table 3 presents the results when the ages of beginning to read and write are included, alternatively. When students start soon with these practices it entails higher achievement in both competences –with the exception of writing for the mathematics competence–. In addition, the effect of a very early start (24 to 35 months) in reading and writing is even higher for both linguistic communication and mathematics –except for early writing in mathematics competence– achievement.

[152] These 2SLS estimations have not been included for reasons of space, but they will be provided upon request to the authors.

[153] The effect of repeaters is almost tripled when it was instrumentalized. Durbin and Wu-Hausman endogeneity tests have been significative at 1% for the estimations including the instrumentalization by the bimester of birth of grade repetition control variable.

[154] They accomplish the relevance requirement but not the validity requirement. In addition, estimation results and postestimation tests do not recommend their use as instruments.

Table 2. Estimation of the conditional effect on academic achievement of socio-economic variables, controlling by repeaters (non-repeaters and repeaters, 1994 cohort)

Variables	Linguistic Communication Competence	Mathematical Competence
Repeaters (*Reference group: Non-repeaters*)	-83.515***	-93.155***
	(6.581)	(6.808)
Female (*Reference group: Male*)	31.151***	-20.188***
	(5.361)	(5.546)
Immigrant (*Reference group: Native*)	-15.079	-38.603**
	(15.785)	(16.331)
Semi-private school (*Reference group: Public school*)	42.350***	13.509*
	(6.699)	(6.931)
Father's education level (*Reference group: Lower than primary*)		
Primary	-6.963	-12.387
	(11.477)	(11.874)
Secondary	5.783	-8.871
	(9.601)	(9.933)
High school	20.109*	0.450
	(11.112)	(11.496)
University	22.531*	-6.203
	(11.785)	(12.193)
Mother's education level (*Reference group: Lower than primary*)		
Primary	-7.455	-5.459
	(12.779)	(13.221)
Secondary	0.891	-6.517
	(11.427)	(11.823)
High school	16.035	16.404
	(12.323)	(12.749)
University	23.584*	17.409
	(12.907)	(13.354)
Monthly income level of the household (*Reference group: 1100 Euros or less*)		
From 1101 to 1800 Euros	9.126	7.405
	(7.225)	(7.475)
From 1801 to 2700 Euros	8.637	15.769*
	(8.837)	(9.143)
More than 2700 Euros	6.258	15.870
	(11.364)	(11.757)
Missing flag	8.739	30.473***
	(10.640)	(11.008)
Constant	490.947***	541.709***
	(13.154)	(13.609)
Observations	1,030	1,030
R-squared	0.307	0.242

Source: Authors' own calculations from ESOC10-SEN.
Estimation method: OLS.
Standard errors in parentheses.
*** denotes variable significant to level 1%; ** to 5%; * to 10%.

Table 3. Estimation of the conditional effect on academic achievement of the ages of beginning to read/write (non-repeaters, 1994 cohort)

Variables	Linguistic Communication Competence		Mathematical Competence	
Additional control variables	✓	✓	✓	✓
Age of beginning to read (*Reference group: 72 months or more*)				
From 24 to 35 months	63.464***		47.630**	
	(18.492)		(19.379)	
From 36 to 47 months	28.154***		19.028*	
	(9.537)		(9.995)	
From 48 to 59 months	23.162***		12.809	
	(8.435)		(8.840)	
From 60 to 71 months	23.142***		15.849*	
	(8.525)		(8.935)	
Missing flag	38.833**		31.471*	
	(15.525)		(16.270)	
Age of beginning to write (*Reference group: 72 months or more*)				
From 24 to 35 months		59.156**		38.079
		(27.037)		(28.316)
From 36 to 47 months		18.915**		7.415
		(9.266)		(9.704)
From 48 to 59 months		20.720***		6.674
		(7.628)		(7.989)
From 60 to 71 months		18.326**		7.978
		(7.538)		(7.895)
Missing flag		21.221		25.329
		(14.927)		(15.633)
Constant	477.717***	484.149***	518.730***	525.481***
	(14.774)	(14.343)	(15.490)	(15.021)
Observations	1,218	1,218	1,218	1,218
R-squared	0.121	0.116	0.075	0.072

The tick (✓) means that additional control variables have been included in the estimates. These are: Sex of the student, immigrant status, funding of the school, education level of the father and the mother and monthly income level of the household.
Source: Authors' own calculations from ESOC10-SEN.
Estimation method: OLS.
Standard errors in parentheses.
*** denotes variable significant to level 1%; ** to 5%; * to 10%.

Table 4 includes as an additional control variable the bimester of birth of the student. Being born in the five first bimesters has a positive effect on students' achievement in the linguistic communication competence, while only the first and fourth bimesters have a positive effect for the mathematics competence. From the view of these results –and comparing with Table 3– it can be concluded that this variable does not take the effect of the ages at which the

student began to read or write, what denotes the robustness of these estimates[155]. These results may be denoting that they are measuring different dimensions of maturity: on the one hand, that related to students' chronological age –the bimester of birth– and, on the other hand, that related to students' mental age –in the case of the ages of beginning to read and write–.

Table 4. Estimation of the conditional effect on academic achievement of the ages of beginning to read/write and the bimester of birth (non-repeaters 1994, cohort)

Variables	Linguistic Communication Competence		Mathematical Competence	
Additional control variables	✓	✓	✓	✓
Age of beginning to read (*Reference group: 72 months or more*)				
From 24 to 35 months	61.191***		44.347**	
	(18.538)		(19.446)	
From 36 to 47 months	28.014***		18.593*	
	(9.534)		(10.000)	
From 48 to 59 months	22.765***		12.240	
	(8.421)		(8.833)	
From 60 to 71 months	22.642***		14.696	
	(8.529)		(8.947)	
Missing flag	37.585**		30.167*	
	(15.550)		(16.312)	
Age of beginning to write (*Reference group: 72 months or more*)				
From 24 to 35 months		54.444**		34.982
		(27.024)		(28.324)
From 36 to 47 months		18.980**		7.463
		(9.259)		(9.704)
From 48 to 59 months		20.084***		6.332
		(7.611)		(7.978)
From 60 to 71 months		17.308**		7.226
		(7.536)		(7.898)
Missing flag		19.147		23.041
		(14.957)		(15.677)
Bimester of birth (*Reference group: Sixth –November, December–*)				
First (January, February)	31.852***	31.821***	32.483***	32.464***
	(10.834)	(10.864)	(11.365)	(11.387)
Second (March, April)	24.065**	25.234**	17.899	19.136*
	(10.671)	(10.690)	(11.193)	(11.205)
Third (May, June)	21.885**	21.207**	12.627	12.429
	(10.611)	(10.640)	(11.130)	(11.152)

[155] In addition, the bimester of birth has been included without the ages of beginning to read and write –keeping the rest of socio-economic variables of Table 1– and its effect is similar to that shown in Table 4. These tables have not been included for reasons of space, but they will be provided upon request to the authors.

Variables	Linguistic Communication Competence		Mathematical Competence	
Additional control variables	✓	✓	✓	✓
Fourth (July, August)	24.935**	26.483**	23.080**	23.874**
	(10.908)	(10.934)	(11.442)	(11.460)
Fifth (September, October)	30.985***	30.105***	12.851	12.334
	(10.876)	(10.919)	(11.408)	(11.445)
Missing flag	17.111*	17.209*	12.751	13.013
	(8.988)	(9.010)	(9.428)	(9.444)
Constant	455.294***	461.861***	502.172***	508.039***
	(16.850)	(16.460)	(17.676)	(17.252)
Observations	1,218	1,218	1,218	1,218
R-squared	0.126	0.121	0.079	0.075

The tick (✓) means that additional control variables have been included in the estimates. These are: Sex of the student, immigrant status, funding of the school, education level of the father and the mother and monthly income level of the household.
Source: Authors' own calculations from ESOC10-SEN.
Estimation method: OLS.
Standard errors in parentheses.
*** denotes variable significant to level 1%; ** to 5%; * to 10%.

Table 5 –Appendix– replicates the same specification as Table 4 but for students born in 1998[156]. Focusing on the bimester of birth, the five first have positive influence on students' linguistic communication and mathematics competences scores –with the exception of the fifth bimester for the linguistic communication competence–. These results also support the importance of an early start in reading and writing in order to increase students' achievement. Hence, the effect of the bimester of birth and the ages of beginning to read and write is maintained for non-repeaters from 10-11 to 14-15 years old.

4. CONCLUSIONS

Maturity has been found in the literature as a relevant element in explaining students' achievement, but it presents the drawback that it is not so easy to measure. Because of that, there have been proposed many proxies for it in the literature, being the most used the quarter of birth. However, this variable has been recently criticized as not being so precise in representing students' maturity. In this context, in order to provide a novel insight into the influence of maturity on students' academic achievement, three dimensions of students' maturity have been proposed in the current work: age at which the student learnt to read and write –proxying mental age–,bimester of birth –representing chronological age– and grade repetition –maturity related to academic knowledge–. This distinction of maturity's dimensions has been reinforced by checking that both the bimester of birth and the ages of

[156] Table 5 –Appendix– has also been estimated by only including the bimester of birth and, in other specifications, including alternatively the ages of beginning to read and write as a robustness check –keeping the rest of socio-economic variables of Table 1–. The results have not changed –what supports the existence of the proposed different dimensions of maturity–. These tables have not been included for reasons of space, but they will be provided upon request to the authors.

beginning to read and write are not proper "substitutes" or instruments of the repeater condition. The main results have also corroborated that they represent different dimensions of students' maturity, as the bimester of birth and the ages of beginning to read and write do not seem correlated when included in the same specification. This supposes a useful approach to the subject of students' maturity –previously studied for Spain only using the quarter of birth, by authors as González-Betancor and López-Puig (2015), or the bimester of birth in Pedraja-Chaparro, Santín, and Simancas (2015)– and also provides information on the effect of this maturity on students' academic pathway.

Dealing with the empirical results, as it could be expected a late start in reading and writing and being born in the last bimester of the year have been found to be detrimental for students' achievement. In addition, these negative effects are kept from 10-11 to 14-15 years old students. Because of that, an important policy implication of this research could be the need to increase investments oriented to provide public support for the early education of students, in order to assure them a proper command on the skills of reading and writing as soon as possible. This could be achieved by the increase in the number of public early education centers and subsidies to help students who are late learners in these skills. Moreover, libraries are also relevant to support the potential lack of educational resources and books in the household, so public investment in these institutions should be fostered. It is also relevant that schools inform parents about the benefits of reading to their children, as it may be favorable for students' reading achievement. It could be advisable to put special emphasis on parents with lower socio-economic background, as they are less likely to perform these practices with their children (Parsons & Bynner, 2007).

Regarding to the bimester of birth, students who were born in the last bimester also need an additional help in order to compensate the lower experience that they could present in relation to their older classmates in the early stages of their academic track. Schools should be aware of it and inform parents about this issue, providing them support in order to sort this problem out. One of the interventions which can help to solve this problem –and also the lack of an adequate level of reading and writing skills– is to provide students with propaedeutic classes where they can reinforce the concepts learned during lessons. In addition, also interesting in the concept of "family-schools" denoted by González (2012), who highlighted the need to improve the relationship of parents with the school and increase their participation, creating an "alliance" between families and school. The positive effects on students' academic achievement of this parental involvement in schools have been remarked by the literature along the years (see, e.g., Stevenson & Baker, 1987; Carvalho, 2000; Benner, Boyle, & Sadler, 2016).

This research presents the previously highlighted limitation that the accuracy of the results related to the ages when students began to read and write is subject to the capacity of parents to remember the exact age when their children started with these practices –a figure which may not be registered by some families–. Nevertheless this is, to some extent, reduced when using interval measures, as stated in our estimates. This drawback is further compensated by the novelty of this research, as the analysis of students' maturity based on three dimensions is –to the best of our knowledge– a less studied field in the Economics of Education literature –

due to the difficulty to find datasets which contain information on these variables simultaneously, especially the ages of beginning to read and write–. This novelty may also set up a precedent for future research, e.g. the analysis of the influence of boys' and girls' differences in maturity endowments on the potential gap between their academic achievements –or their high school track choices–.

REFERENCES

Alet, E. (2010). *Is grade repetition a second chance?* Toulouse School of Economics Working Paper.

Ammermüller, A. (2007). Poor Background or Low Returns? Why Immigrant Students in Germany Perform so Poorly in the Programme for International Student Assessment. *Education Economics, 15*(2), 215–230.

Arce, M. E., Crespo, B., & Míguez-Álvarez, C. (2015). Higher Education Drop-Out in Spain—Particular Case of Universities in Galicia. *International Education Studies, 8*(5), 247–264.

Barua, R., & Lang, K. (2011). *School Entry, Educational Attainment and Quarter of Birth: A Cautionary Tale of LATE*. NBER Working Paper no. 15236.

Bedard, K., & Dhuey, E. (2006). The persistence of early childhood maturity: international evidence of long-run age effects. *Quarterly Journal of Economics, 121*(4), 1437–1472.

Benner, A. D., Boyle, A. E., & Sadler, S. (2016). Parental Involvement and Adolescents' Educational Success: The Roles of Prior Achievement and Socioeconomic Status. *Journal of Youth and Adolescence*, in press.

Bruquetas, C., & Martín, R. (2012). *La educación en las familias andaluzas: Expectativas, prácticas y rendimiento escolar. Informe de resultados*. IECA Documentos de trabajo no. 7.

Buckles, K., & Hungerman, D. (2010). *Season of Birth and Later Outcomes: Old Questions, New Answers*. NBER Working Paper no. 14573.

Calero, J., Choi, A., & Waisgrais, S. (2010). Determinantes del riesgo de fracaso escolar en España: una aproximación a través de un análisis logístico multinivel aplicado a PISA-2006. *Revista de Educación, Extraordinary vol.*, 225–256.

Carvalho, M. E. P. (2000). *Rethinking family-school relations: a critique of parental involvement in schooling*. London: Routledge.

Cohen, V. L., & Cowen J. E. (2008). *Literacy for Children in an Information Age: Teaching Reading, Writing, and Thinking*. Stamford: Wadsworth Thomson.

Creed, P. A., & Patton W. (2003). Predicting Two Components of Career Maturity in School Based Adolescents. *Journal of Career Development, 29*(4), 277–290.

Cunha, F., Heckman, J. J., Lochner, L., & Masterov, D. V. (2006). Interpreting the Evidence on Life Cycle Skill Formation. In E. Hanushek, & F.Welch (Eds.), *Handbook of the Economics of Education* (pp. 697–812). North Holland: Elsevier.

De la Fuente, A., & Serrano, J. F. J. (2013). La rentabilidad privada y fiscal de la educación en España y sus regiones. *Moneda Y Crédito, 235*, 179–246.

García-Pérez, J. I., Hidalgo-Hidalgo, M., & Robles-Zurita, J. A. (2014). Does grade retention affect achievement? Some evidence from PISA. *Applied Economics, 46*(12), 1373–1392.

González, O. (2012). *Familia y escuela/Escuela y familia: Guía para que padres y docentes nos entendamos*. Bilbao: Desclée De Brouwer.

González, A., & De la Rica, S. (2012). *Gender Gap in PISA Test Scores: The Impact of Social Norms and the Mother's Transmission of Role Attitudes*. IZA Discussion Paper no. 6338.

González-Betancor, S. M., & López-Puig, A. J. (2015). Escolarización temprana, trimestre de nacimiento y rendimiento educativo en primaria. *Revista de Educación, 369*, 159–183.

Gutiérrez-Domènech, M., & Adserà, A. (2012). Student performance in elementary schools. *Revista de Economía Aplicada, 20*(59), 135–164.

Hidalgo-Hidalgo, M., & García-Pérez, J. I. (2012). Impacto de la asistencia a educación infantil sobre los resultados académicos del estudiante en primaria. In MECD (Ed.), *PIRLS - TIMSS 2011. Volumen II: Informe Español. Análisis Secundario* (pp. 190-239). Madrid: Instituto Nacional de Evaluación Educativa.

IECA (2015). *Tasa de abandono escolar prematuro por sexo*. Retrieved from http://www.juntadeandalucia.es/institutodeestadisticaycartografia/indsoc/indicadores/1038.htm.

Kaplan, R. M., & Saccuzzo, D. P. (2013). *Psychological Testing: Principles, Applications and Issues, 8th*. Pacific Grove, CA: Wadsworth Cengage Learning.

Marcenaro, O. (2012). *Resumen del informe "La función de producción educativa para el caso de Andalucía: un análisis desde la perspectiva cuantitativa y cualitativa"*. IECA Documentos de trabajo no. 6.

MECD (2011). *Evaluación General de Diagnóstico 2010. Educación Secundaria Obligatoria. Segundo Curso. Informe de resultados*. Madrid: Instituto de Evaluación.

MECD (2013). *PISA 2012. Programa para la Evaluación Internacional de los Alumnos. Informe español. Volumen I: Resultados y contexto*. Madrid: Ministerio de Educación, Cultura y Deporte.

Neuman, S. B., Copple, C., & Bredekamp, S. (2000). *Learning to Read and Write: Developmentally Appropriate Practices for Young Children*. Washington: National Association for the Education of Young Children.

OECD (2010). *PISA 2009 at a Glance.* OECD Publishing.

OECD (2014). *Are boys and girls equally prepared for life?* OECD Publishing.

Parsons, S., & Bynner, J. (2007). *Illuminating Disadvantage: Profiling the experiences of adults with Entry level literacy or numeracy over the lifecourse.* NRDC research report.

Pedraja-Chaparro, F., Santín, D., & Simancas, R. (2015). Determinants of grade retention in France and Spain: Does birth month matter? *Journal of Policy Modeling, 37*(5), 820–834.

Plug, E., & Oosterbeek, H. (1999). *Is schooling a family thing? Effects of grandparents, parents, brothers and sisters on school choices.* TSER meeting Working Paper no. 15–99.

Ponzo, M., & Scoppa, V. (2014). The Long-Lasting Effects of School Entry Age: Evidence from Italian Students. *Journal of Policy Modeling, 36*(3), 578–599.

Robertson, E. (2011). The effects of quarter of birth on academic outcomes at the elementary school level. *Economics of Education Review, 30*(2), 300–311.

Stern, W. (1912). *Die psychologische Methoden der Intelligenzprufung*. Leipzig, Germany: Barth.

Stevenson D. L., & Baker, D. P. (1987). The Family-School Relation and the Child's School Performance. *Child Development, 58*(5), 1348–1357.

APPENDIX

Table 5. Estimation of the conditional effect on academic achievement of the ages of beginning to read/write and the bimester of birth (non-repeaters, 1998 cohort)

Variables	Linguistic Communication Competence		Mathematical Competence	
Additional control variables	✓	✓	✓	✓
Age of beginning to read (*Reference group: 72 months or more*)				
From 24 to 35 months	16.281		11.439	
	(17.572)		(17.758)	
From 36 to 47 months	35.532***		35.324***	
	(8.224)		(8.310)	
From 48 to 59 months	17.651**		20.041***	
	(7.320)		(7.397)	
From 60 to 71 months	23.902***		19.021***	
	(7.226)		(7.302)	
Missing flag	-2.031		-3.545	
	(14.347)		(14.498)	
Age of beginning to write (*Reference group: 72 months or more*)				
From 24 to 35 months		11.446		10.084
		(21.536)		(21.693)
From 36 to 47 months		27.592***		35.893***
		(7.817)		(7.874)
From 48 to 59 months		17.708***		22.314***
		(6.547)		(6.595)
From 60 to 71 months		19.005***		21.293***
		(6.363)		(6.409)
Missing flag		-4.808		-8.603
		(14.242)		(14.346)
Bimester of birth (*Reference group: Sixth –November, December–*)				
First (January, February)	18.337**	19.446**	31.083***	32.288***
	(9.196)	(9.219)	(9.293)	(9.286)
Second (March, April)	24.633***	25.520***	22.333**	22.963***
	(8.803)	(8.827)	(8.896)	(8.891)
Third (May, June)	19.130**	20.090**	19.243**	19.752**
	(9.013)	(9.028)	(9.108)	(9.093)
Fourth (July, August)	18.115**	18.739**	18.775**	19.012**
	(9.195)	(9.212)	(9.292)	(9.279)
Fifth (September, October)	14.436	13.945	24.091***	23.863***
	(9.066)	(9.088)	(9.162)	(9.154)
Missing flag	16.432**	17.311**	23.412***	23.806***
	(7.433)	(7.446)	(7.511)	(7.500)
Constant	429.484***	431.717***	435.796***	434.505***
	(13.039)	(12.550)	(13.176)	(12.641)
Observations	1,868	1,868	1,868	1,868
R-squared	0.114	0.111	0.112	0.114

The tick (✓) means that additional control variables have been included in the estimates. These are: Sex of the student, immigrant status, funding of the school, education level of the father and the mother and monthly income level of the household.
Source: Authors' own calculations from ESOC10-SEN.
Estimation method: OLS.
Standard errors in parentheses.
*** denotes variable significant to level 1%; ** to 5%; * to 10%.